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ABSTRACT

Provided in this guide are resources for these 11 topics: the physical/geological ocean; the chemical/biological ocean; the ocean's coasts; fishing and aquaculture; tourism, recreation, and development; mining and drilling; research and exploration; maritime and military; ocean technology; pollution; and resource management. These resources include: (1) an overview of the topic; (2) a list of references and resource materials (such as curriculum guides, activities, books, pamphlets, films, and books); (3) a list of careers related to the topic; (4) a list of periodicals related to the topic; and (5) action items (suggested activities for students and teachers to complete). Also listed are additional resources, including periodicals, special resources (indicating organizations and the types of materials/services they provide), organizations for students, and two sources for obtaining career information guides. Materials under $5 are noted. (JN)

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year of the ocean
PRESENTS

Ocean Prospects:

a high school teacher's guide to ocean-related topics

SE 046 059

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Key

Each page gives an overview of a specific ocean-related topic with concentration on current issues. The **References and Resources** on each page are both references and sources of additional material. Addresses not given in the text may be found in the **Additional Resources** pages. "MEMS" refers to material available through the Marine Education Materials System (back cover). New or important words and phrases are in bold italic. **Careers** section lists only a few careers in ocean-related fields for each topic. For more information contact sources listed on back under "Career Information." The questions posed are to encourage further reading. The answers are not necessarily within this guide, but rather in the resource reading.

Materials under $5 or free are indicated.

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TO THE TEACHER...

This resource guide was conceived by the Year of the Ocean Foundation to assist teachers who will be instructing the nation's first ocean-literate generation. The intent is to provide you and your school system with up-to-date information on the science, industry, recreation, careers, management and future of our most abundant resource.

The ocean is our history, a major food source, a cache of valuable oil, gas and minerals. It is ships and navies, marine science and tourists; all are part of this wonder that covers 70 percent of our planet.

This resource will direct you to curriculum guides, activities, books, films, periodicals, and public and private organizations which have thoughtfully designed programs for educators--no matter where they live or how limited their funds. In fact, many of the materials are free or available for minimal costs.

Most Sea Grant programs offer summer courses for teachers and students. There are public and private organizations which sponsor volunteer opportunities, research studies or summer programs just for fun. Marine industries produce excellent information packets and films, provide speakers, and if you're close enough, give tours. The United States Navy and Coast Guard also can provide educational materials, career information, speakers, and films on a variety of ocean topics.

All of the organizations listed in this guide are enthusiastic supporters of marine education, and most have been actively involved in the Year of the Ocean Foundation's initiatives. These organizations welcome your requests for materials and information.

Why take the time to teach about the oceans? Because our lives and fortunes depend on it. The research, international meetings, economic studies and initiatives of the past ten years have brought us to an exciting threshold. With continued momentum, we can enter a new age of ocean exploration and management. That new age will require skilled professionals, an ocean-literate society, and a renewed sense of excitement about our future on earth.

The Year of the Ocean Foundation established public awareness and education as primary goals. You are the key to achieving those goals.

The ocean holds a strong fascination for nearly everyone. The elements of wonder and drama inherent in the ocean world can be used to engage the attention and enthusiasm of students. We hope that **Ocean Prospects** will appeal to your curiosity, resourcefulness, and imagination. We also hope it will be merely a starting point to ocean adventures for you and your students.

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Earth-shaking discoveries.
Floating continents and "new" oceans.
Plate tectonics theory revolutionizes oceanography.

The Physical/Geological Ocean

THE PHYSICAL PROPERTIES OF THE OCEAN DERIVE FROM THREE BASIC ELEMENTS--THE WATER, THE OCEAN BASIN WHICH IS THE WATER'S CONTAINER, AND THE MOVEMENT OF THE WATER WITHIN THE CONFIGURATION OF THE BASINS.

There are two major theories for the origin of water on earth. One is that it formed early in the earth's history, and the other is that the water has gradually been derived from the earth's interior. However it arrived, the same water has been recycled through the hydrosphere throughout geologic time.

For all its familiarity, water is unique among chemical compounds in a number of ways. The fact that water expands, and therefore floats when frozen, has far-reaching effects on world climate. If ice sank, the polar seas would freeze solid, permanently, and glaciers would cover most of the earth. Water also absorbs tremendous amounts of heat, far more than land, which helps to maintain the earth's warmth. The average temperature of the ocean is 30-40° F.

REFERENCES AND RESOURCES

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Film: **Continental Drift: The Theory of Plate Tectonics**. 16 mm. video-cassette. 22 mins. No. 3652. Encyclopedia Britannica Education Corp., 425 N. Michigan Ave., Chicago, IL. (Rental)

PERIODICALS: Sea Frontiers, Sea Technology, Oceans, Oceanus.

CAREERS: Physical oceanographer, geologist, meteorologist, physicist, underwater technician, marine technician.

The earth, as we recognize it, emerged when a thin skin solidified over hot fluids. As the earth's atmosphere continued to cool, the skin or ***crust***, developed cracks. In those cracks, called ***rifts***, hot fluid or ***magma*** rose, cooled, and built the earth's surface, the ***plates***. Over millennia the floating plates collided and joined, separated again at the weak seams, and repeated variations of the process until a combination of physical and mechanical forces pushed a group of plates together, raised a portion of their surface and created a ***super-continent*** surrounded by a shallow ocean. Eventually, the super-continent split up and the pieces drifted apart, leading to the formation of the present ocean basins and the arrangement of the present land masses. The continents continue to drift and new oceans are being formed all the time. Rifts in the plates bring upwellings of magma which cool and flow down the ridge crests forming new oceanic crust. These rifts occur in mid-ocean ridges which circle the globe. The oceanic crust is much thinner and newer than the land surface. These discoveries are all part of the theory and study of plate tectonics.

The waters of the oceans are acted upon by wind, gravity and the attraction of the moon and sun. The earth's primary winds result from the rotation of the earth and drive the ocean waves. Heated, less dense water at the equator creates a ski-slope effect north and south with gravity enhancing the resulting currents. The Coriolis force bends the currents into circulation patterns which are interrupted by continents or eventual collision with opposing currents. Deep ocean circulation is generated primarily by the sinking, cold water from the South Pole which forms a circum- Antarctic current and branches which flow south to north.

The tides are long waves created by the gravitational attraction of the moon and the sun to the earth. The waves have a period of twelve hours and twenty-five minutes and a wave length of half the circumference of the earth. The crest and the trough of the wave are known as high tide and low tide. Tide range varies around the world from eight inches to 50 feet.

ACTION ITEMS:
Teachers: Contact universities or Sea Grant programs for courses in physical oceanography.
Students: Visit an old strip mine or site of an old ocean, anywhere that you can see the layers of the earth. Determine how those layers were deposited, and what materials comprise each layer.

WHO WAS ALFRED WEGENER?

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The Chemical/Biological Ocean

Chemists investigate new metal deposits.
Life without light surprises biologists.
Needed – chemists and chemical engineers.

SEAWATER IS A SOLUTION OF DISSOLVED SOLIDS, AN AVERAGE OF 35,000 PARTS PER MILLION, MOSTLY CHLORINE AND SODIUM. THE RELATIVE AMOUNTS OF DISSOLVED ELEMENTS IN THE OCEAN ARE CONSTANT.

Fifty-seven elements are found in perceptible quantities in seawater. Chlorine is the most common element at 89,500,000 tons per cubic mile, and gold is the least common at .02 tons per cubic mile. Most of the elements are derived from the erosion of the continents. Sediments containing elements are transported down rivers, picked up by ocean currents and then distributed throughout the oceans.

New metal deposits are being formed in the mid-ocean ridges. Naturally corrosive seawater percolates through cracks and fissures in the young, still hot rocks to considerable depths and then leaches certain elements. This process, called ***hydrothermal metallogenesis***, offers new insights into the origins of the earth's chemical composition. The composition of ***ophiolites***, deposits found on land, are similar to the composition of deposits observed at the ocean basin creation sites.

Hydrogenous deposits accrete from seawater and slowly accumulate on the sea floor. Called ***manganese nodules***, these irregularly shaped spheres contain metallic elements. Nodules rich in copper, cobalt, and manganese are of strategic and economic value.

The physical and chemical properties of the ocean determine the nature of life there. At the base of the food chain are microscopic plants and animals which are usually loosely classified according to habitat.

Plankton are drifters on the surface, nekton are swimmers, and the benthos are bottom dwellers.

The ***phytoplankton*** are plants that utilize light and inorganic nutrients, and are moved about by the ocean's circulation system. The majority of animals in the ocean are ***zooplankton*** which feed on the phytoplankton. There are about 1,000 phytoplankters in the ocean for every zooplankter ten times the size; and about one million billion such plankton for every filter- feeding whale thirty feet long.

Until recently, scientists thought the only important food chain in the ocean was the one similar to that on land – plants using light for photosynthetic fixing of carbon. Then studies at ***hydrothermal vent*** sites revealed an extensive food chain based on ***chemosynthesis***. Around the vents, sometimes thousands of feet beneath the ocean surface, there is no light. Hydrogen sulfide sometimes turns the waters milky. Yet in what would be a hostile cauldron to most life, the energy released by the oxidation of hydrogen sulfide is used by bacteria to reduce carbon dioxide to organic carbon. These chemosynthetic bacteria are the bottom of a complex and diversified food chain completely separate from the ocean's primary, photosynthetic-based chain.

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•Somero, George N. 1984. "Physiology and Biochemistry of the Hydrothermal Vent Animals." **Oceanus** 27(3):67-72.

•Trefil, James. 1984. **A Scientist at the Seashore**. Charles Scribner's Sons. New York, NY.

Film: **Life in the Open Ocean**. 1978. 2 filmstrips. National Geographic Society, 17th and M Sts., NW, Washington, D.C., 20036.

CAREERS: Chemist, chemical engineer, geochemist, biologist.

PERIODICALS: Calypso Log, Current, Sea Frontiers and Sea Secrets, Freshwater and Marine Aquarium, Nautica, Underwater Naturalist, Oceans, Oceanus.

ACTION ITEMS:

•**Teachers**--set up a saltwater aquarium. References: 4-H Marine Education Project Guide by Barbara S. Waters, **Small Oceans**. (Under $5.) Or, **The Marine Aquarium, The Science, Animals and Art**, by Stephen Spotte. Or, an instructional film on setting-up an aquarium and the chemistry involved, **The Tropical Marine Aquarium**. Videocassette, 30 mins. For brochure, write: Video Enterprises, P.O. Box 13636, Richmond, VA, 23225.

•**Students**--attend a sea camp. Contact a Sea Grant program or the Cousteau Society (addresses in back) or the American Sail Training Association, Eisenhower House, Ft. Adams State Park, Newport, RI 02840 for information.

WHAT IS *Riftia pachyptila*?

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Ocean meets land, dramatic and dynamic.
Lost civilizations found on the shelf.
An abundance of life.

The Ocean's Coasts

THE OCEANS AND THE CONTINENTS ARE TWO VERY DISTINCT ECOLOGICAL ENVIRONMENTS. THAT WHICH BINDS THEM TOGETHER AND FORMS THE PHYSICAL AND BIOLOGICAL INTERFACE IS REFERRED TO GENERALLY AS THE "COAST." IT CONSISTS OF THE CONTINENTAL SHELF, THE SHORELINE AND THE COASTAL PLAIN.

The ***continental shelf*** is the physical part of the continental land mass, which is underwater. Over the past 250 million years, the continental shelf has alternately emerged or submerged as sea level fluctuated by as much as 300 feet. In some coastal areas, years of sea level rise have caused the coastline to retreat as much as 70 miles inland over the past 20,000 years.

The ***shoreline*** is an ephemeral feature, always in a state of change from the forces of waves, storms, sea level fluctuations, and ***sediment*** movements from land erosion and ***coastal sediment transport***. Dramatic changes occur from catastrophic events such as hurricanes or earthquakes. The 1964 Alaskan earthquake raised a section of the continental shelf (the size of the state of Florida) nearly forty feet in a few minutes.

REFERENCES AND RESOURCES

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•Coulombe, Deborah A. 1984. **The Seaside Naturalist: A Guide to Nature Study at the Seashore**. Prentice-Hall, Inc., Princeton, NJ.

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•Fox, William T. 1983. **At the Sea's Edge: An Introduction to Coastal Oceanography for the Amateur Naturalist.** Prentice-Hall, Inc., Princeton, NJ.

•Mavor, James W., Jr. 1985. "Atlantis and Catastrophic Theory." Oceanus 28(1):44-51.

Film: **Portrait of a Coast**, 16 mm. 29 mins. Circle Oak Productions, 73 Girdle Ridge Dr., Katonah, New York, NY 10536. (Rental)

PERIODICALS: Underwater Naturalist, International Journal of Nautical Archaeology and Exploration, Sea History.

The ***coastal plain*** is composed of the lower water shed and the estuarine system it creates which flows into the oceans along the coasts. This intricate system transports sediments, nutrients and fresh water into the ocean and vitalizes the most productive marine environment. Because the estuaries and the shelf are relatively shallow, allowing light penetration, 90 percent of marine life is found here. Coastal features such as ***marshes*** provide ideal breeding grounds; riverine habitats afford protection to juvenile organisms. In transition zones between salt and fresh water, along rocky, sandy or muddy shores, marine plants and animals proliferate. Of the 200,000 marine species, two percent live near the surface of the open sea, far fewer on the deep sea floor, and all the rest in the shallows and intertidal zones of the coasts.

Scientists studying the coastal climate-induced changes over the millennia, may have unearthed answers to questions which have puzzled historians for centuries. Civilizations which appear to have vanished overnight may have been forced to vacate coastal areas due to relatively sudden changes in coastal sea level or because of climatic changes brought about by dramatic alterations in coastal currents.

Underwater archaeologists bring the stories of these civilizations to light. Better understanding of the ocean's geological and physical changes has increased our knowledge of history. Advanced recovery and preservation techniques permit study and restoration of the artifacts retrieved from "lost" coastal civilizations.

ACTION ITEMS:

•**Teachers**--Take a summer trip or weekend course with the American Littoral Society.

•**Students**--Begin a sand-trade collection. Correspond with schools on various coasts. Study their ecology and trade sand samples. If you're inland, act as a broker for schools around the country and in foreign countries.

**Contact the nearest Sea Grant Program for regional publications on the coasts. You may wish to collect publications from each coastal area: Atlantic, Pacific, Gulf, Alaskan, Hawaiian, and Great Lakes.

WHAT IS SAND?

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Fishing and Aquaculture

U.S. seafood consumption up 20 percent.
Extension of U.S. fishing zone increases U.S. landings.
Have you tried surimi?

THE PREDOMINANT ORGANIC MATERIAL ON LAND IS CARBOHYDRATE, BUT IN THE SEA IT IS PROTEIN. FISH AND SHELLFISH ARE EXCELLENT SOURCES OF HIGH-QUALITY PROTEIN.

Fish protein is easily digested and almost completely absorbed. It is high in polyunsaturated fats and low in cholesterol. Americans' growing concern over healthy diet and the relatively low cost of finfish have increased U.S. consumption by 20 percent in the past few years. Last year, Americans ate an average of 13.6 pounds of seafood per person.

Commercial landings by U.S. fishermen from estuaries and coasts in ports of the 50 states amounted to 6.4 billion pounds valued at $2.5 billion in 1984. The United States imports $5.9 billion worth of edible and non-edible fish and exports a little less than $1.0 billion. About 3.0 billion pounds of fish are caught in U.S. waters by foreign fisheries, primarily Japan and Korea. Protective legislation, however, has increased the proportion of U.S. fisheries catches within the ***Exclusive Economic Zone*** (EEZ), which extends 200 miles off the coast. The varieties most harvested from these waters in order of value are: shrimp, salmon, crab, lobster, clams, flounders, tuna, menhaden, oysters, cod, sea herring, rockfish, squid, anchovies, ocean perch.

The most popular commercial fishing gear is the ***trawl***. This wide-mouthed net is dragged along the bottom to capture bottom-dwellers such as flounder, or through mid-water for mackerel. Fishermen also trawl for shrimp, one of the most valuable fisheries products.

Longline fishing is the common method for catching tuna, halibut, red snapper and swordfish. The line, which can be 10 miles long with buoys and baited hooks attached, is left in the water for a few hours and then hauled back and inspected for catch.

Gill nets are also used to catch fish. Salmon are just one of the species landed by this method. The ***purse seine***, a great circular net with a draw-string, can capture large schools of fish such as menhaden and herring. These heavy nets are brought in by hydraulic devices that pull the filled nets onto the vessel's deck.

Since the world-wide demand for seafood is increasing, and the ocean does not have a limitless supply (see Resource Management page 12), research and industry have sought ways to protect the resource and provide the seafood people want. One of the most exciting products on the food market is ***surimi***, a product developed by Japan. Surimi is a fish paste mixed with a tasty shellfish or flavoring and then restructured into a desired shape and texture. Surimi makes use of ***underutilized fish species*** such as pollock, and requires only a minimum amount of an expensive and often limited species such as crab. If flavoring is used, real seafood is not needed. The National Marine Fisheries Service has dedicated $1.5 million for development of the U.S. surimi industry; an industry which yearly nets $60 million for the Japanese in U.S. sales. At present, surimi is restructured into simulated crab, scallop, shrimp and lobster.

Another growing industry imported from southeast Asia is ***aquaculture***. In 1977, world aquaculture production provided approximately 10 percent of fisheries products, or about 12 billion pounds; 65 percent of which came from Asia. This industry produces approximately 93 species of finfish, seven species of shrimp or prawns, six species of crayfish and numerous bivalve molluscs and marine plants.

Catfish farming, a $200 million U.S. industry, leads the list of farm-raised fish. Mississippi farmers raise 85 percent of the 150 million pounds produced annually. Salmon aquaculture methods are referred to as ***"ocean ranching"*** because young fish are released into the ocean and then harvested when they return to spawn. ***Seaweed*** is a major component of Asian diets, but primarily an additive in the dairy, medical, pharmaceutical and cosmetic industries in the United States.

REFERENCES AND RESOURCES

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•Stillings, B.R. & Thompson, M.H. 1978. **Seafoods for Health**. National Marine Fisheries Service. Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. No. 003- 020-00144-1. (Under $5)

•Unknown. 1984. **Fisheries of the United States**. 1984. National Marine Fisheries Service, NOAA, Washington, DC 20235. (Available through most state or public libraries.)

•Various Authors. 1985. **Lobster Tales**. Red Lobster Inns of America. 6770 Ellenor Drive, Orlando, FL 32859. (Free)

POSTERS: Educational Marine Life Posters from National Marine Fisheries Service. Order from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

PERIODICALS: National Fisherman, Underwater Naturalist, Nautica, Current

CAREERS: Icthyologist, economist, biologist, chemist, resource manager, fisherman, aquaculturist.

ACTION ITEMS:

•**Teachers**--Arrange with a local Extension Agent or school home economist to study and serve seafood, including surimi.

•**Students**--Take part in local fish tagging, stocking, or monitoring projects through 4-H, Fish and Wildlife Service or local environmental or recreational fishing organization.

Which seafood product is highest in protein, but is lowest in calories?

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It's the number one tourist location.
Highest priced acreage in the country.
Jobs for young people.

Tourism, Recreation & Development

TOURISM, RECREATION, AND OCEAN DEVELOPMENT IN THE COASTAL AREA ARE BIG BUSINESS. ACCORDING TO THE U.S. TRAVEL DATA CENTER IN WASHINGTON, D.C., THE BEACH IS THE NUMBER ONE CHOICE FOR SUMMER VACATIONS.

Boating, recreational diving, fishing, surfing and just visiting the coast are activities which support multi-billion dollar industries. Boating, for instance, is a $12 billion business in the United States. There are 6,000 marinas, boatyards and yacht clubs in operation. In 1984, approximately 15.5 million Americans water-skied at least once during the year.

In the United States, citizens spend 6.5 percent of their expendable income for recreation. Increased income coupled with increased leisure time makes tourism, recreation, and their service-related industries such as restaurants and hotels, a booming business with no end in sight. These industries also offer opportunities to young and unskilled labor unparalleled in any other U.S. business sector. Many vocational programs are now offering high school students training in these fields.

REFERENCES AND RESOURCES:

•Edgell, R. 1985. **Marine Recreational Highlights**. No. 34:4-5, National Marine Fisheries Service, Washington, D.C.

•Lucy, J., Breen, A. and Rigby, D. 1985. **Urban Waterfronts: Positive Directions, New Problems**. Sea Grant Marine Communications Office, Virginia Institute of Marine Science, Gloucester Point, VA 23602 (Under $5.)

•Unknown. 1984. "The Boating Business." **Boating Industry**, 850 Third Avenue, New York, NY 10022.

PERIODICALS: Periodicals abound on recreational activities, generally by specific topics such as: fishing, boating, sailing, diving, surfing.

For developers, the coastal areas have become the most lucrative markets in real estate. An average acre of farm land in the United States is valued at $695, the most productive about $2,000. On the coast, that range is $35,000 to $125,000 an acre. Those figures are expected to escalate as more and more people move to the coast. The recent census reports that 65 percent of the population now lives within 50 miles of our nation's coasts. That figure is expected to jump to 75 percent by the turn of the century.

This coastal development, both industrial and residential, leads to conflicts. One of the major problems for vacationers is public access. As an example, the state of Virginia has over 5,000 miles of tidal shoreline, but the public has free access to only 28 miles. California has legislated increased public access for much of their coastline. This allows more people use of the shore, and also prevents development in an area which is so volatile that the federal government has stopped assuring flood insurance to developers and individuals who ignore the hazards.

Americans stream to the beaches each year, from Coney Island to Malibu, to the Gulf States' "gold coast" and to the Great Lakes' emerald green waters. There are coastal resorts to suit every taste, from Victorian-style family hotels to the sophisticated Atlantic City gambling casinos. In Louisiana, tourists can take a ride through the bayous in perogues with Cajun guides and on Alaska's pristine estuaries fishermen from all over the country line the banks once a year for salmon fishing.

In recent years, many inner-city shorelines have been revitalized and are now major tourist attractions. These areas have also become prime conference centers, another growing coastal business.

The United States is also an increasingly popular tourist site for visitors from foreign countries. These visits have spurred the growth of airport facilities, hotels, restaurants and retail businesses.

ACTION ITEMS:

Teachers and Students--Write to the Chamber of Commerce in individual cities or state tourism departments and request information about vacation and coastal recreational activities. Contact a local travel agent for posters, brochures and other information.

"Coastal Adventures:

•The Chewonki Foundation, RFD 3, Box 3400C, Wiscasset, ME 04578. Marine and inland ecology workshops and wilderness trips.

•Earthwatch, Box 127da, Belmont, MA 02178. Record the behavior of harbor and gray seals on the remote island of Miquelon, off Newfoundland.

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Mining and Drilling

Strategic products.
State-of-the-art technology and research.
Career opportunities abound in the petroleum industry.

ONE OF THE CURIOSITIES THE *HMS CHALLENGER* BROUGHT BACK FROM ITS HISTORIC VOYAGE IN 1872 WERE "CONCRETIONARY LUMPS" FROM THE DEEP WATERS OF SEVERAL OCEANS. IT WASN'T UNTIL AFTER WORLD WAR II THAT UNDERWATER CAMERAS REVEALED THAT MILLIONS OF SQUARE MILES OF THE OCEAN FLOOR WERE COVERED WITH THESE LUMPS, NOW KNOWN AS MANGANESE NODULES.

During the 1970s, national and international consortia began developing technology to mine the ocean's rich metal deposits. Copper, manganese and cobalt are three vital metals found in quantities sufficient for mining. Manganese and cobalt are strategic metals critical for hardening steel. It takes 900 pounds of cobalt for the production of just one F-16 aircraft engine. The United States imports 90 percent of these metals from politically unstable countries. Because both U.S. industry and defense depend on steel production, the metals are kept in reserves.

Several mining technologies were developed during the first research studies. At the present time, the most economically feasible technique appears to be a sort of giant underwater vacuum cleaner that sucks up the nodules on the seabed 10,000 to 20,000 feet beneath the surface. A mineral collector with a dredge-like suction nozzle is attached to a pipeline which connects to the mining ship.

An international moratorium was imposed on mining the oceans until 1988. Scientists wanted more time to study the environmental effects of deep ocean mining, and international arguments occurred over who should have access to the potentially valuable harvest (see Resource Management page 12).

Sand and gravel, found closer to shore, are the first materials being mined from the ocean in quantity. Both materials are required by the construction industry. Ocean mining of sand and gravel offers an environmentally and economically sound alternative to borrow pits on land.

The petroleum industry has explored and extracted ocean resources for over eighty years. Petroleum deposits began forming about a billion years ago when the remains of some of the earth's earliest life forms accumulated on the bottom of the ancient oceans and formed huge beds of ***calcium carbonate***. These were compressed and cemented into ***sedimentary rocks***. Eventually, with heat and time, some of those organic deposits which were confined within non-porous rock formations or traps, turned to petroleum.

The United States uses about 6 billion barrels of oil a year. Seventy percent of our energy is derived from petroleum products. One-third of U.S. petroleum needs are imported.

Thirteen percent of domestic crude oil and 24 percent of natural gas presently come from the ocean. For planning purposes, the ***outer continental shelf*** (OCS) is the term used to describe the area where most underwater exploration and drilling take place. This area, under federal regulation, extends from 3-10 miles from shore to the edge of the ***Exclusive Economic Zone***.

The first ocean drilling was performed in the early 1900s from piers off the coast of California. In the late 1930s, the first offshore field was discovered in the Gulf of Mexico, and the first producing well was completed in 1947, 12 miles off the coast of Louisiana.

Geophysicists use three primary methods for finding petroleum deposits: a ***gravimeter*** detects gravitational differences in the submerged rocks; a ***magnetometer*** detects variations in the earth's magnetic field; and ***seismic devices*** interpret sound waves bounced off rock layers beneath the ocean bottom. In more shallow waters, ***infrared aerial photography*** and ***satellite imagery*** may give clues to an area's geology.

Although specialized technology and equipment are required for deepwater drilling, the principles are similar to those used on land. A drilling derrick is located on the ocean craft or platform, and the drilling operation is performed from the deck(s).

REFERENCES AND RESOURCES:

•Hopson, J.L. 1981. "Miners are reaching for metal riches on the ocean floor." **Smithsonian**. 12(1):50-59.
•Knecht, Robert W. 1982. "Deep Ocean Mining." **Oceanus**. 25(3):3-11.
•Unknown. 1976. **The case for deep ocean mining**. American Mining Congress. 1100 Ring Building, Washington, DC 20036 (Free)
•Unknown. 1984. **Geophysics in Petroleum Exploration**. American Petroleum Institute. (Free)
•Unknown. 1984. **Oil, Gas and Deepwater Technology: The Hidden Frontier**. American Petroleum Institute. (Free)
Film: **Energy Choices**. 16mm/videocassette. 21 mins. each. Four-part program covering natural gas, domestic oil and gas production, synthetic and renewable fuels and conservation. Film and curriculum program are FREE ON LOAN. Contact Tenneco, Inc. Public Affairs Dept., P.O. Box 2511, Houston, TX 77001.

PERIODICALS: Sea Technology, The Marine Technology Journal, Oceans, Oceanus.

CAREERS: Geophysicist, oceanographic equipment engineer, mechanical engineer, petroleum geologist, geological technician, computer programmer.

ACTION ITEMS:
For Teachers and Students--Few subjects have stirred such controversy across the United States as the energy needs vs. conservation and environmental protection arguments of the past ten years. Examine current literature and economic factors available and review **all sides** of the issues.

BEST COPY AVAILABLE

Adventure stories worth reading.
International cooperation.
From submersibles to satellites.

Research & Exploration

THE *HMS CHALLENGER* SET SAIL IN 1872 WITH THE ROYAL DIRECTIVE TO "LEARN EVERYTHING ABOUT THE SEA." A HUNDRED YEARS LATER, THE *R/V GLOMAR CHALLENGER* BEGAN A 15-YEAR PROJECT OF DISCOVERY THAT REVOLUTIONIZED OCEANOGRAPHY BY BRINGING BACK PROOF OF THE THEORY OF PLATE TECTONICS, BUT STILL LEAVING MUCH TO LEARN.

The history of oceanographic research and development is an adventure story of human endeavors and technologic development. From ***LT Mathew Fontaine Maury's*** first observations in the 1850s to ***William Beebe*** and ***Otis Barton's bathysphere*** dive in the 1930s, the young science grew. Then, stimulated and financed by the military during World War II, oceanography advanced beyond ***Jules Verne's*** visions. ***Jacques Yves Cousteau*** and ***Emile Gagnan*** perfected the aqualung and regulator which permitted people to swim freely and work up to 200 feet below the surface. Sonar, developed to detect submarines, was fine-tuned along with seismography and used to map the ocean bottom.

As a result of the successful projects of the *R/V Glomar Challenger*, the Joint Oceanographic Institutions Deep Earth Survey (JOIDES) has embarked on a ten-year program of deep ocean studies in their new vessel, the *R/V Resolution*. In addition to continued core sampling, the scientists aboard *R/V Resolution* will place instruments on the deep ocean floor for continuous sensing.

REFERENCES AND RESOURCES:

•Amidei, Rosemary. 1985. **California and the Pacific, Exploring the Exclusive Economic Zone**. California Sea Grant College Program, University of California, La Jolla, CA 92093. (Free)

•Briggs, Peter. 1971. **200,000,000 Years Beneath the Sea**. Holt, Rinehart and Winston, New York, NY.

•Dugan, James. 1967. **World Beneath the Sea**. National Geographic Society, Washington, DC.

•Guberlet, Muriel L. 1964. **Explorers of the Sea: Famous Oceanographic Expeditions**. Ronald Press Company, New York, NY.

•Hauser, H., Hawkes, G., & Ballard, R. 1983. "Undersea Systems." **Oceans**. 16(2):14-19.

•Revelle, Roger. 1969. "The Age of Innocence and War in Oceanography." **Oceans**. 1(3):5-14.

Films: **Antarctica: Exploring the Frozen Continents**. 16mm/videocassette. 22 mins. Story of major explorations, past and present. Encyclopedia Britannica Educational Corporation, 425 N. Michigan Ave., Chicago, IL 60611. (Rental)

Offshore. 16mm/videocassette. 18 mins. Offshore Exploration. Includes free teacher discussion material. Modern Talking Picture Service, Inc. Film Scheduling Center, 5000 Park St., N. St. Petersburg, FL 33709. (Free on loan)

PERIODICALS: The Marine Technology Society Journal, Naval Institute Proceedings, Sea Frontiers, Calypso Log, Sea History, The International Journal of Nautical Archaeology and Underwater Exploration, Sea Technology.

CAREERS: Oceanographer, research vessel Master or crew, naval engineer, naval architect, design engineer.

In 1977, scientists in the submersible "Alvin" hovered over a hydrothermal vent at 8,182 feet. Their research provided the key to understanding the geologic origin of land-based polymetallic sulfide deposits. Today, submersibles like "Wasp," "Argo-Jason," and "Scorpio" are designed for specific types of observation, sampling, photography, or sensing tasks at great depths and in places previously inaccessible to researchers.

In the past five years, natural product chemists have discovered at least 1500 new compounds from marine organisms. Over 150 of these compounds display antimicrobial, anti-tumor, anti- inflammatory or cardiotonic activities. This research is greatly expanding medically-related marine science studies.

Using photos and other images from space, meteorologists and oceanographers are working together to understand current movements, climate variations and other ocean and atmospheric patterns which are interrelated. The new studies use a combination of atmospheric observation stations, satellites, ships, shore stations and drifting buoys.

Oceanographic research is costly. Most major projects, like JOIDES, are international, often with a combination of public and private funding. The University-National Oceanographic Laboratory System (UNOLS) represents the U.S. academic research fleet. Individual university projects are funded through private foundations, business, states or the federal government. The U.S. Navy and the National Oceanic and Atmospheric Administration (NOAA) conduct their own research and fund private and university projects. Industrial-academic research projects benefit both parties, and have increased significantly in the past ten years.

ACTION ITEMS

Teachers and Students: Explore the depths! Learn snorkeling--in a pool, a lake, a river, or the ocean. Contact a qualified diving or swimming instructor for lessons.

WHO WERE HENRY BIGELOW, T. WAYLAND VAUGHAN AND THOMAS G. THOMPSON?

BEST COPY AVAILABLE

Maritime & Military

Giant container ships and "Old Ironsides." Floating air strips and dramatic rescues at sea. Heritage and future.

THE MERCHANT MARINE LINKS U.S. MANUFACTURERS AND FARMERS WITH THE DOMESTIC AND FOREIGN MARKETS, DELIVERS RAW MATERIALS TO INDUSTRY, AND PLAYS A VITAL ROLE IN THE NATION'S DEFENSE CAPABILITY.

The United States merchant marine includes every commercial vessel that flies the U.S. flag. Vessels range from small tramp freighters to supertankers. They carry oil, chemicals, machinery, food and other cargoes vital to the economy.

Larger merchant vessels today are designed for specific types of cargo. Roll on/Roll off (RO/RO) ships enable longshore workers to drive vehicles on board and off again. If ever needed, they can be quickly modified to transport military vehicles around the world. Other vessels are Oil/Bulk Ore (OBO) ships and Liquified Natural Gas (LNG) ships. Lighter Aboard Ships (LASH) and Sea Barge (Seabee) ships carry loaded barges, which at the end of a sea trip are put into the water and hitched up to a tug that tows them to their destination. Ocean cruise ships or liners carry passengers all over the world as a means of elegant transportation and provide complete vacations onboard.

Container ships carry specially designed 20 foot x 8 foot x 8 foot containers which are loaded directly from tractor-trailer trucks or trains onto the ships and off-loaded directly at the end of the voyage. Recently, U.S. Lines received the first of a new fleet of container ships. These 950 foot sophisticated vessels carry 4,500 containers and are crewed by just 21 merchant officers and seamen.

Merchant marine officers are educated at either the U.S. Maritime Academy or one of several state-supported maritime colleges. Even in this age of instant ship-to-shore communications capability, these highly skilled professionals are still responsible for the lives and safety of their crews, vessels and cargo in sometimes life-threatening situations.

Thirty-five years ago, the United States was the world's greatest shipping and shipbuilding nation. Today, America is eighth in shipping and sixteenth in shipbuilding. At the end of World War II there were 2,000 ocean-going ships bearing the American flag. Today there are only 631 American flag vessels. In 1984 only ten merchant vessels were built in U.S. shipyards. At present the existence of U.S. shipyards depends on U.S. Navy contracts.

The United States Navy was established by the Congressional Congress in 1775. The first ships built were ordered in 1794 by President Thomas Jefferson. Of the first three frigates built, two are still in existence. The *Constellation*, berthed in Baltimore, Md., is open to the public. The *Constitution*, affectionately called "Old Ironsides" is the oldest commissioned vessel in the U.S. Navy and may be visited in Boston, Mass.

The Navy's purpose is to defend the United States in wartime, to maintain open sea lanes for merchant trade, and to use its presence around the world to help maintain peace. The modern Navy boasts approximately 580 ocean-going vessels, the largest of which are the Nimitz class carriers. These floating air strips are 1,045 feet in length, displace 91,400 tons, and carry a crew of 6,000.

The U.S. Coast Guard is the vital link beteeen the military and maritime world in the United States. Established in 1790 to enforce all federal maritime laws and treaties and to protect lives and property, the Coast Guard is the smallest branch of the military. During peacetime, the Coast Guard comes under the jurisdiction of the Department of Transportation. In time of war it comes under the Department of Defense.

Recently, the Coast Guard was given the added mission of coastal defense, but wherever there is navigable water in the United States, the Coast Guard is on duty. Their efforts on behalf of private citizens, mariners and maritime property are truly legendary. They are perhaps best known to the public for their search and rescue operations which often include harrowing helicopter rescues of ill or injured sailors from ships or small boats at sea.

REFERENCES AND RESOURCES:

-Abranson, Erik. 1976. **Ships of the High Seas**. Eurobook, Ltd. London, England.

-Unknown. **The United States Merchant Marine, A Brief History**. U.S. Department of Transportation. MEMS 02236. (Under $5.)

Contact the following agencies or organizations and ask for information.

U.S. Coast Guard, Commandant, USCG(G-BPA-3), Washington, D.C. 20593 (Free)

U.S. Navy, contact local Naval Reserve Center or Navy Recruiting Office; ask for "Sea Power," presentation (Free)

Shipbuilder's Council of America, 1110 Vermont Ave., NW, Washington, D.C. 20005 (Free)

The Propeller Club of the U.S., 1030 15th St., NW, Suite 430, Washington, D.C. 20005

Film: **Sea Trials**. 16 mm/videocassette. 30 mins. FREE ON LOAN. Write Bath Iron Works Film Library, 5000 Park Street North, St. Petersburg, FL 33709. (Maritime life in the '80s)

PERIODICALS: U.S. Naval Institute Proceedings; Sea History; News Briefs of the American Maritime Officers Service, 923 15th St., NW, Washington, D.C. 20005

CAREERS: U.S. Coast Guard and U.S. Navy. (Career opportunities are limited at present in the U.S. maritime industries.)

ACTION ITEMS

-**Teachers**--The maritime and ocean-going world are rich in fiction and non-fiction reading. Request bibliography: **A List of Books on the Marine Environment**. University of Delaware Sea Grant Program. MEMS 000083. (Under $5.)

-**Students--WIN A FREE CRUISE**: The Propeller Club of the U.S. sponsors an annual essay contest. Most areas of the country are eligible. For information, write: The Propeller Club of U.S., 1030 15th St., N.W., Suite 430, Washington, D.C. 20005.

WHAT IS SEA POWER?

BEST COPY AVAILABLE

Careers in engineering.
Super-tankers and computers.
Surviving the elements.

Ocean Technology

ON THE OCEAN SURFACE, STORMS MAY WHIP UP WAVES 60 FEET, AND WINDS CAN BLOW 200 MILES PER HOUR. UNDER THE SURFACE, WATER PRESSURE INCREASES **1 ATMOSPHERE (14.7 lbs. per square inch) EVERY 33 FEET**; SO THAT AT DEPTHS OF 10,000 FEET, THE PRESSURE IS 4,200 POUNDS PER SQUARE INCH.

Saltwater is naturally corrosive. At the ocean depths there is no light, and the rugged terrain can be treacherous. Still, people persist in exploring, studying and working on the surface and in the depths of the ocean. To do so, they have developed specialized and sophisticated marine engineering technology.

Super-tankers, over 1,000 feet long, some carrying highly toxic chemicals, ply the ocean trade routes. Their cargoes are loaded, monitored, and off-loaded by computerized systems which can also adjust pressure and temperature to maintain safe passage.

A unit of Shell Oil Co. is currently building the world's tallest **offshore drilling platform**. The 1,615-foot platform will be taller than the Chicago Sears Tower, presently the world's tallest building at 1,454 feet.

REFERENCES AND RESOURCES:

•Amidei, Rosemary. 1985. **California and the Pacific: Exploring the Exclusive Economic Zone**. California Sea Grant College Program, University of California, La Jolla, CA 92093. (Free)

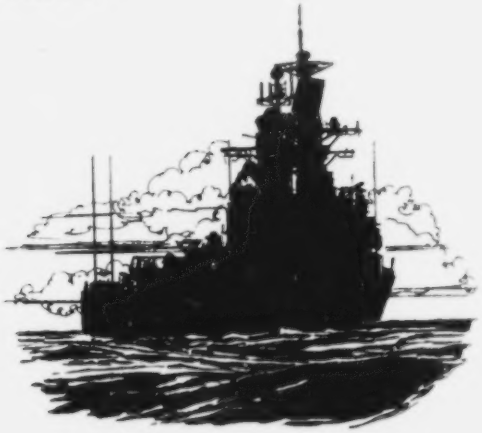
•Falvey, Thomas J. 1985. "Vessel Traffic Services." **Sea Technology**. 26(6):20-24.

•Smith, Ned P., Ed. 1984. **Harbor Branch Profiles III**. Harbor Branch Foundation, Inc. Fort Pierce, FL 33450.

•Unknown. 1984. **Keeping American Maritime Industry Competitive**. American Merchant Marine Conference Proceeding. Volume 50. Portland, OR.

PERIODICALS: Sea Technology, Sea Frontiers, Calypso Log, Journal of the Marine Technology Society.

CAREERS: ***GOOD EMPLOYMENT OUTLOOK***. Ocean engineer, oceanographic equipment engineer, electrical engineer, systems programmer, marine technician.



Exploration vessels and drilling rigs also work in the Beaufort Sea, northwest of Alaska, and in the North Sea off Scotland; two of the most hostile environments in the world.

Less than a hundred years ago, explorers first entered the Arctic and Antarctic, but today, work in extreme cold and on polar ice are commonplace. For the future, industry is working on designs for over-ice transport, lighter-than-air transport, ice-breaking transport ships, and subsea pipeline designs for the polar regions.

Marine salvage increases in sophistication with the vessels it must retrieve. Salvage ships are designed to prevent environmental damage, bring back valuable property, and remove navigational obstacles.

In areas where navigation is particularly heavy, such as the English Channel and large ports such as New York City, computer-enhanced radar systems monitor vessel traffic. Ship's Masters and Pilots are "brought in" just as aircraft pilots are directed to runways.

Satellite navigation systems are so precise that a site or even a drill hole can be relocated on the ocean floor (relocation and re-entry systems). Using a computer-enhanced navigation system, vessels can be held on location (dynamic positioning) for research or industrial purposes.

Research and exploration vessels carry sonar, gravimeters, heat probes, seismographs, chromatographs, mass spectrometers and a host of other sensing, measuring, and analyzing devices so preliminary research results can be obtained at sea. Larger research vessels carry submersibles for deep ocean research. Using hydraulic wenches, the mother vessel easily lowers or raises the research submersible into and out of the water.

Ocean technology offers some of the greatest challenges for scientists, engineers and designers. Environmentally and economically sound exploitation of the ocean will depend on future technology.

ACTION ITEMS:

Teachers and Students: Contact local engineering organizations for information on career opportunities and educational requirements. Also write: The Institute of Electrical and Electronics Engineers, 345 East 47th Street, New York, NY 10017, and The Marine Technology Society, 1730 M St., NW, Washington, DC 20036. Both organizations sponsor minority education programs.

Pollution

Understanding the terms.
Taking ACTION.

POLLUTION IS GENERALLY DEFINED AS THE RESULT OF SUBSTANCES INTRODUCED INTO THE ENVIRONMENT BY HUMAN ACTIVITIES WHICH ARE DETRIMENTAL TO PLANTS AND ANIMALS.

Changes can take place in an ecological system from natural occurrences such as volcanoes or unusually high levels of fresh water entering an estuary due to storms or snow melt. The effects are usually short term. Pollution, however, may continue for such a long time and at such a rate, that the ecological systems affected have neither time nor resources to recover from one onslaught before being impacted by ten or a hundred more.

Because the coastal area is the most productive in terms of numbers of organisms and because this area is closest to human activity, it is the most subjected to pollution. It is important to remember that the oceans of the world flow together and that the hydrosphere (water cycle) is a closed system. While the results of near shore pollution may be the most obvious and the most researched, the deep ocean is also being polluted. Just how rapidly and significantly is largely unknown. Full understanding may be decades away.

In the most simple classification, pollution may be divided into eight categories:

(1) ***nutrients***--dissolved inorganic elements and compounds which increase photosynthetic activity. Sewage is among the most common nutrient sources.

(2) ***oxygen consuming materials***--chemical and biological additions which remove dissolved oxygen from the water. Examples are sewage and organic matter.

(3) ***particulate matter***--finely dissolved particles which remain in the water column for long periods of time. Their eventual settlement may have detrimental effects on benthic organisms. Examples are silts from dredging, or erosion, or particulate matter from industrial discharges.

(4) ***toxic substances***--chemicals that cause death or which block or slow down physiological processes. These include thousands of biocides and toxic materials from human activities such as industrial outfalls, non-point sources, mine leaching.

(5) ***heat (thermal energy)***--temperature increases in an aquatic environment may cause complex changes. Heat can increase biological activity to a certain point beyond which organisms suffer distress.

(6) ***radioactive wastes***--elements and compounds emitting ionizing radiation. Long-term health hazard affecting all living organisms.

(7) ***water diversions*** --excess fresh water introduced into an estuary or excess salt added to fresh or brackish water. An example is outfall from a desalination plant.

(8) ***trash***--non-degradable refuse. Six million tons per year are dumped in the ocean.

Any of the above primary pollutants may combine to form ***synergistic substances***. For instance, toxic wastes may combine with an organic material under heated conditions and the resulting substance may or may not further pollute the ecosystem.

REFERENCES AND RESOURCES:

•Hastie, Bill. Rev. 1985. **Water, Water Everywhere.** (See Inside Back Cover.)

•Kaufman, W. and Pilkey, O. H., Jr. **The Beaches are Moving: The Drowning of America's Shoreline 1983.** Part of a series, Living With the Shore. Duke University Press, Durham, NC.

•Soule, D.F. and Walsh, D. 1983. **Waste Disposal in the Oceans: Minimizing Impact, Maximizing Benefits.** Westview Press, Boulder, CO.

•Teal, John and Mildred. 1969. **Life and Death of a Salt Marsh.** Little, Brown, Boston, MA.

Films: **Estuary.** 1981. 12 mins. 16mm/videocassette. National Film Board of Canada. Bullfrog Films, Oley, PA 19547. (Rental)

A Need To Know. 1982. 16 mm. 28 mins. Chemical Manufacturers Association. Modern Talking Picture Service, Film Scheduling Center, 5000 Park Street North, St. Petersburg, FL 33709. (Free on loan)

The Man Who Talks to Water. 16 mm. 28 mins. Ameron Corporation. Modern Talking Picture Service. (See above) (Free on loan)

PERIODICALS: Clean Water Action News (address below), Oceanus, Journal of Soil and Water Conservation, 7515 NE, Ankeny Rd., Ankeny, IA 50021-9764.

CAREERS: Bio-chemist, environmental planner, engineer, waste disposal technician, analytical chemist

ACTION ITEMS:

Teachers and Students--Write Clean Water Action Project, 733 15th St., NW, Suite 1110, Washington, D.C. 20005. National, non-profit citizen's group working for "Clean and safe water at an affordable cost." Become involved in local projects. Write for free information.

The key to the ocean and mankind's future.
Putting it all together.

Resource Management

EVERY LIVING THING ON EARTH IS A "USER" OF RESOURCES. RESOURCE MANAGEMENT IS A WAY OF BALANCING HUMAN NEEDS WITH THOSE OF ALL OTHER ELEMENTS OF THE ENVIRONMENT AND WITH CONFLICTS AMONG PEOPLE.

The perfect management model exists when humans and other organisms or systems use a resource without depleting or damaging it. Understanding is fundamental to management.

Much of the damage to our coastal, estuarine and ocean environments was caused by ignorance. Economics also play a role. It is perceived as less expensive to dump our cities' refuse into the ocean than to develop alternatives. However, the cost of poor resource management is more expensive in the long run.

Water is necessary for the survival of all living things on earth. Yet in many areas of the world, including parts of the United States, water is in short supply and/or unfit for use by plants, animals or people. Acid rain, ocean dumping and discharge and indiscriminate use of water adversely impact the water of every nation.

A conference held in 1972, referred to as "The London Dumping Conference," specifically addressed ocean pollution. This agreement set down international guidelines for ocean dumping including discharges from land, ships, and offshore facilities, toxic & nuclear waste disposal and chemical or oil spill control.

In an effort to regulate ocean use, negotiations were conducted for 15 years by most of the world's nations. In 1982, the **Convention on the Law of the Sea** treaty set rules for all parts and virtually all uses of the ocean. Much of the negotiation was concerned with **sovereignty**; i.e., navigation, security and the laws of coastal nations. One hundred fifty-one nations signed the treaty, but the United States and several other major nations declined. Congress viewed restrictions on deep ocean exploration, among other problems, as inconsistent with U.S. interests.

Meetings among fishing nations have been conducted for several years. One of their concerns is setting fishing limits or **maximum sustainable yields**. It has been determined that a world fishery of 110 to 120 million metric tons is the maximum amount which can be harvested, maintain a viable industry and protect the resource. A combination of fishery limitations and management, plus the development of aquaculture and use of underutilized species may enable all people to continue to enjoy the ocean's plants and animals without damaging those resources.

Another major effort by resource managers involves **mitigation.** Planners and regulators, using scientific data, attempt to work out compromises which benefit users and the environment.

Coastal zone management is a specialized branch of management which seeks understanding, regulation and wise use of the complex coastal system (see The Ocean's Coasts page 4). Coastal zone managers hope to resolve the conflicts between users without damage to the resource, industry and the economy or the public interest.

REFERENCES AND RESOURCES:

•Brown, G.M. & Crutchfield, J.A. 1982. **Economics of Ocean Resources: A Research Agenda**. University of Washington Press, Seattle, WA.

•Gopalakrishnan, Chennat. 1984. **Emerging Marine Economy of the Pacific**. Butterworth Publishers, Boston, MA.

•Kwiatkowska, Barbara. 1984. "Marine Pollution from Land-Based Sources: Current Problems and Prospects. **Ocean Development and International Law**. 14(3):315-331.

Sullivan, Wm. L., Jr. 1985. "Is there a national ocean policy?" **Ocean Development and International Law**. 15(1):77-88.

•Various Authors. 1984/85. "The Exclusive Economic Zone." (Special Issue). **Oceanus**. Volume 27, Number 4.

Film: **The Pollution Solution?** 1977. 16mm/ video-cassette. 15 mins. U.S. National Aeronautics and Space Administration. Contact: U.S. General Services Administration, National Archives and Records Service, National Audiovisual Center, Order Section/RE, Washington, DC 20409. (Rental)

PERIODICALS: Oceanus; Ocean Development and International Law, Crane, Russak & Co., Inc. 3 East 44th St., New York, NY 10017; Coastal Zone Management Journal, Crane, Russak & Co., Inc.; Underwater Naturalist.

CAREERS: Resource manager, economist, marine scientist, planner

ACTION ITEMS:

Teachers and Students: Attend a meeting of local zoning board or your state soil and water conservation department hearings, or U.S. Army Corps of Engineers public hearings on environmental use projects in your area. Teachers and students can set up resource management situations from their locality or by researching a matter of national or international concern.

BEST COPY AVAILABLE

PERIODICALS:

•CALYPSO LOG. The Cousteau Society, 930 West 21st St., Norfolk, VA 23517.

•CURRENT. The Journal of Marine Education, NMEA, P.O. Box 666, Narragansett, RI 02882.

•FRESHWATER AND MARINE AQUARIUM. R/C Modeler Corp., P.O. Box 487, Sierra Madre, CA 91024.

•THE INTERNATIONAL JOURNAL OF NAUTICAL ARCHAEOLOGY AND UNDERWATER EXPLORATION. Academic Press, Inc., 111 Fifth Ave., NY, NY 10003.

•THE MARINE TECHNOLOGY SOCIETY JOURNAL. 2000 Florida Ave., NW, Washington, DC 20009.

•NATIONAL FISHERMAN. 21 Elm St., Camden, ME 04843.

•NAUTICA. Spinnaker Press, Inc. Pickering Wharf, Salem, MA 01970.

•OCEANS. Journal of the Oceanic Society, P.O. Box 10167, Des Moines, IA 50340.

•OCEANUS. The Magazine of Marine Science and Policy. Woods Hole Oceanographic Institution, Woods Hole, MA 02543.

•U.S. NAVAL INSTITUTE PROCEEDINGS, Annapolis, MD 21402.

•SEA FRONTIERS. International Oceanographic Foundation, 3979 Rickenbacker Causeway, Virginia Key, Miami, FL 33149. Also publishes SEA SECRETS, an educational service of the Foundation.

•SEA HISTORY. National Maritime Historical Society, 132 Maple St., Croton-on-Hudson, NY 10520.

•SEA TECHNOLOGY. Compass Publications, Inc., Suite 1000, 1117 N. 19th St., Arlington, VA 22209.

•UNDERWATER NATURALIST. Bulletin of the American Littoral Society, Sandy Hook, Highlands, NJ 07732.

FOR SPECIAL RESOURCES

•THE UNITED STATES GEOLOGICAL SURVEY (USGS) has prepared a special packet of teaching aids for secondary school teachers of Earth Science. These packets include such topics as "The Interior of the Earth," "Earthquakes," "Volcanoes," and "Marine Geology: Research Beneath the Sea." These packets are FREE, but you must follow instructions for requesting. (1) Request on school letterhead, (2) Indicate the subject or subjects you teach (packets are also prepared for other levels and subjects), (3) Indicate grade level and (4) Attach a mailing label for the package. Type your address; do not use addressograph. Send to USGS, Geologic Inquiries Group, Mail Stop 907, Reston, VA 22092.

•THE AMERICAN PETROLEUM INSTITUTE (API) has a selection of materials on careers, arctic research, offshore exploration techniques; economic and resource facts. Packets are FREE. Indicate that you are a teacher. American Petroleum Institute, 1220 L Street, NW, Washington, D.C. 20005.

•WATER, WATER, EVERYWHERE, from the Extension Sea Grant Program of Oregon State University. The Teacher's Guide (Revised 1985) is both a curriculum and resource guide for educators. Sent with the guide is an order form with descriptions of 31 marine-related topics, each with activities. Vicki Osis, Marine Science Center, Newport, OR 97365. (Under $5.)

•THE PROPELLER CLUB OF THE UNITED STATES. A non-profit organization to "promote, further and support an American Merchant Marine and to aid the development of river, Great Lakes and harbor improvements." Write to them for a diverse package of maritime information, plus instructions concerning their student essay contest which is open to most high school students. **Students may win a cruise**. Bibliography for maritime interests, also. Headquarters, 1030 15th Street, NW, Suite 430, Washington, D.C. 20005. (FREE)

BEST COPY AVAILABLE

NATIONAL MARINE EDUCATORS ASSOCIATION. Non-profit; educators, administrators, marine research, government, aquarists. To stimulate communication among all persons interested in the marine environment and to assist educators. NMEA, P.O. Box 666, Narragansett, RI 02882.

THE OFFICE OF SEA GRANT. Sea Grant institutions in 30 states maintain programs in research, education and advisory services to foster increased understanding and wise use of the oceans and Great Lakes. Education efforts range from marine technology to K-12 curriculum development. For a list of institutions and programs: Office of Sea Grant, NOAA, U.S. Department of Commerce, 6010 Executive Blvd., Rockville, MD 20852.

CENTER FOR ENVIRONMENTAL EDUCATION, Inc. Private, non-profit, environmental concern and education. Publishes DIRECTORY OF MARINE EDUCATION RESOURCES. Center for Environmental Concern, 624 9th St., NW, Washington, D.C. 20001.

MARINE EDUCATION MATERIALS SYSTEM. Two thousand documents relating to marine and aquatic education have been collected, accessed and indexed. Microfiche copies. Literature searches. Write for the MEMS brochure. MEMS, Virginia Sea Grant College Program, Virginia Institute of Marine Science, Gloucester Point, VA 23062.

NATIONAL SCIENCE TEACHERS ASSOCIATION. Non-profit educational organization and an affiliate of the American Association for the Advancement of Science. Publishes THE SCIENCE TEACHER. 1742 Connecticut Ave., NW, Washington, D.C. 20009.

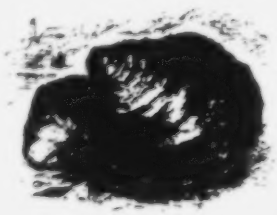
ORGANIZATIONS FOR STUDENTS:

4-H, hands-on experience and activities for students of all ages, anywhere in the country. Special activities in marine science. Contact local Extension Agent through Department of Agriculture.
Girl Scouts and Boy Scouts. Both groups have special programs and training in marine-related topics. Contact local Boy Scout or Girl Scout Council. **Sea Explorers**. Primarily located in areas near water access. Co-ed, youths 14 to 21. Everything from sea shantys to sailing. Contact the Boy Scouts of America.

CAREER INFORMATION GUIDES

OCEAN OPPORTUNITIES. Marine Technology Society, 1730 M St., NW, Washington, D.C. 20036. (Under $5.)

OCEAN FRONTIERS: The United States Navy and Oceanography. Office of the Oceanographer of the Navy, Washington, D.C. 20235. (FREE)



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